Tobacco Control 1994; 3: 362–369

From the US Food and Drug Administration

The control and manipulation of nicotine in cigarettes

David A Kessler

On 25 March 1994 the Commissioner of the US Food and Drug Administration (FDA), Dr David Kessler, presented testimony to the Subcommittee on Health and the Environment, US House of Representatives, on the addictive nature of cigarette smoking and possible tobacco industry manipulation of nicotine levels in cigarettes. That testimony was reproduced in the Summer 1994 issue of Tobacco Control *(1994; 3:148–58).*

On 21 June 1994 Dr Kessler reappeared before the same subcommittee, and presented testimony on genetic and chemical manipulation of nicotine content. This statement is reproduced below. Twenty-two charts, which for the most part duplicated material in the text, have been omitted. Also, some of the references have been modified to conform to the journal's style. Otherwise, the testimony is reproduced in its original form. – ED

In my last appearance before this subcommittee on 25 March 1994, I raised the question of whether the FDA should regulate nicotine-containing cigarettes as drugs under the Federal Food, Drug, and Cosmetic Act.[1] A product is a drug if its manufacturer intends it to be used to affect the structure or function of the body.[2] Because of the enormous social consequences of such a decision, we have asked Congress for guidance as we try to answer this question.

Mr Chairman, the American public owes a huge debt of gratitude to this subcommittee for its tireless efforts to focus attention on this most important public health matter.

Let me begin by summarising the information that I presented at that hearing. I reviewed the evidence that supports the scientific consensus that nicotine is addictive. I also reviewed the evidence we had at that time on the ability of the tobacco industry to control nicotine levels, including numerous industry patents for technologies to manipulate and control nicotine content. I described activities of the cigarette industry that resemble those of pharmaceutical manufacturers. I presented information that raised the question of whether tobaccos were blended to manipulate and control nicotine levels. And I provided data showing that over the last decade, nicotine levels have not dropped in parallel with tar levels – in fact, they have risen.

Since March 25th we have continued to focus our analysis and investigation on the physiological and pharmacological effects of nicotine and on the degree to which cigarette companies manipulate and control the level of nicotine in their products.

The information that I presented about industry control and manipulation of nicotine the last time I testified before you was suggestive. Today I am going to provide you with actual instances of control and manipulation of nicotine by some in the tobacco industry that have been uncovered through painstaking investigational work over the last three months.

We have discovered that manipulation of nicotine has been carried out by some even before tobacco seeds were planted in the fields. We have discovered other forms of manipulation that occur later, in the design and manufacture of cigarettes.

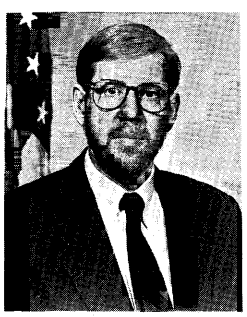
Today I want to discuss two examples of nicotine manipulation in some detail. First, we have discovered the deliberate *genetic* manipulation of the nicotine content in a tobacco plant. It is the story of how an American tobacco company spent more than a decade quietly developing a high-nicotine tobacco plant, growing it in Central and South America, and using it in American cigarettes. Second, I will discuss how chemical compounds are added to cigarettes to manipulate nicotine delivery.

Genetic manipulation of nicotine content

The project I am going to tell you about led to development of a tobacco plant code-named "Y-1". It has been an enormous task to piece together the picture of Y-1. Confidentiality agreements have made getting the facts very difficult.

The story begins in Portuguese with our discovery of a Brazilian patent for a new variety of a flue-cured tobacco plant (figure 1).[3] One sentence of its English translation caught our eye. "The nicotine content of the leaf of this variety is usually higher than approximately 6% by weight... which is significantly higher than any normal variety of tobacco grown commercially."[4]

Prior to our discovery of the patent, an industry executive had told us that "flue-cured tobacco naturally contains 2.5 to 3.5 percent nicotine."[5] Thus, this new specially bred plant would contain approximately twice the nicotine that occurs naturally in flue-cured tobacco.



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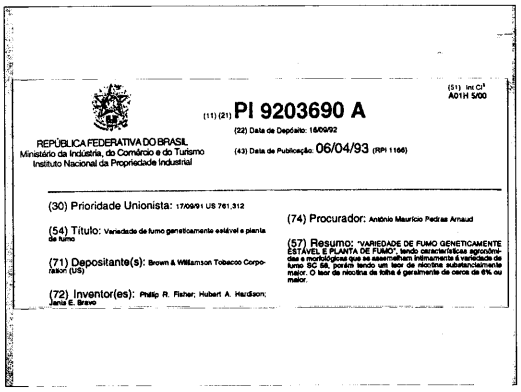

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REPÚBLICA FEDERATIVA DO BRASIL
Ministério da Indústria, do Comércio e do Turismo
Instituto Nacional da Propriedade Industrial

(30) Prioridade Unionista: 17/09/91 US 761,312

(54) Título: Variedade de fumo geneticamente estável e planta de fumo

(71) Depositante(s): Brown & Williamson Tobacco Corporation (US)

(72) Inventor(es): Philip R. Fisher; Hubert A. Hardison; Jamie E. Bravo

(74) Procurador: Antônio Maurício Pedras Arnaud

(57) Resumo: "VARIEDADE DE FUMO GENETICAMENTE ESTÁVEL E PLANTA DE FUMO", sendo caracterizadas agronômicas e morfológicas que as assemelham intimamente à variedade de fumo SC 58, porém tendo um teor de nicotina substancialmente maior. O teor de nicotina da folha é geralmente de cerca de 6% ou maior.

Figure 1

The holder of the Brazilian Y-1 patent was Brown & Williamson Tobacco Corporation, maker of such cigarettes as Kool, Viceroy, Richland, Barclay, and Raleigh.

Let me tell you why this discovery interested us. Industry representatives have repeatedly stated for the public record that they do not manipulate nicotine levels in cigarettes. The plant described in this patent represents a dramatic attempt to manipulate nicotine.

Moreover, when we asked company officials whether plants were bred specifically for higher nicotine content, we were told that this was not feasible. We were told that tobacco growers and cigarette manufacturers have an agreement that the nicotine level of new varieties of tobacco grown in the US can vary only slightly from the levels of standard varieties. Under this agreement, a new high-nicotine tobacco plant that varied more than slightly from the standard variety could not be commercially grown by farmers in the US.

Nevertheless, we learned that interest in developing a high-nicotine tobacco plant dates back to at least the mid-1970s. In 1977, Dr James F Chaplin, then of both the US Department of Agriculture (USDA) and North Carolina State University, stated:

"manufacturers have means of reducing tars but most of the methods reduce nicotine and other constituents at the same time. Therefore it may be desirable to develop levels constant or to develop lines higher in nicotine so that when the tar and nicotine are reduced there will still be enough nicotine left to satisfy the smoker."[6]

In fact, Dr Chaplin had been working on genetically breeding tobacco plants with varying nicotine levels. In a 1977 paper, Dr Chaplin indicated that tobacco could be bred to increase nicotine levels, specifically by cross breeding commercial varieties of tobacco with *Nicotiana rustica*. *N rustica* is a wild variety, very high in nicotine, but not used commercially in cigarettes because it is considered too harsh.[7]

Dr Chaplin has told us that his specially bred plants were not commercially viable because they did not grow well and literally did not stand up in the field. Furthermore, he was surprised that he could not get the nicotine levels as high as he anticipated. In fact, in his 1977 paper, the highest nicotine level he reported in these specially bred lines was 3.4% total nicotine, within the normal range for flue-cured tobacco.

At the same time, international efforts focused on controlling and manipulating nicotine by alternative methods. For example, the use of reconstituted tobacco:

"... [LTR, a maker of reconstituted tobacco] which homogenises tobacco for various European cigarette houses cannot only reduce the tar in the sheet it sends back to clients; it is able to work into client's scrap and waste new tobacco of the *rustica* type, rich in nicotine, in order to change the relationship of nicotine and tar in the sheet. It is able to do the same by the alternative method of adding salts of pure nicotine into the slurry that eventually becomes tobacco sheet. This is an operation parallel to, though more exact than, that on which US geneticists are engaged, in seeking to develop types of tobacco that are low in tar but fairly rich in nicotine."[8]

Over the next several years Dr Chaplin continued his efforts to breed a tobacco plant with a higher nicotine level. During that time, an employee of a Brown & Williamson-affiliated company asked Dr Chaplin for some of his seeds. Some of Dr Chaplin's original plant varieties were used as a basis for Brown & Williamson's work. From what we can gather, there was no formal release of this high-nicotine tobacco variety for private use. In the early 1980s, Brown & Williamson grew a number of different plant lines on its experimental farm in Wilson, North Carolina, selecting those that had the best agronomic characteristics.

In 1983, Brown & Williamson contracted with DNA Plant Technology to work on tobacco breeding. Much of the developmental work on Y-1 took place in the laboratories, greenhouses, and fields owned by DNA Plant Technology. After he retired from USDA, in 1986, Brown & Williamson also hired Dr Chaplin as a consultant to work on Y-1 and other projects.

The high-nicotine tobacco variety Y-1 was developed by a combination of conventional and advanced genetic breeding techniques (figure 2). These include traditional crosses and back crosses between different plant varieties and more sophisticated state-of-the-art breeding techniques including anther culture (figure 3), tissue culture (figure 4), hybrid sorting, and protoplast fusion (figure 5) that resulted in cytoplasmic male sterility. The

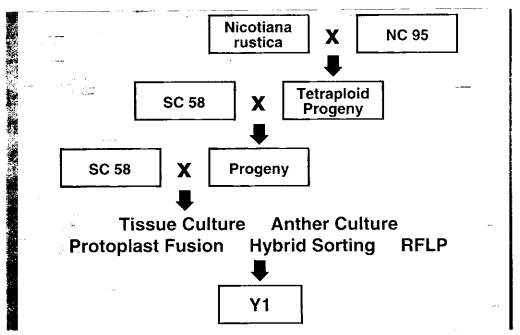


Figure 2 The breeding of Y-1. Sources: Brazilian Patent PI 9203690A and DNA Plant Technology Corporation

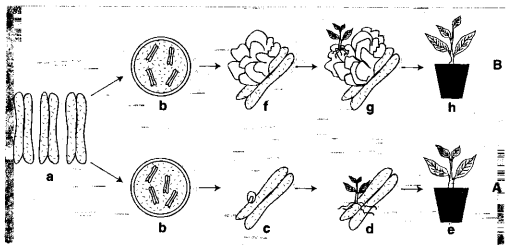


Figure 3 Anther culture. Source: Breeding field crops *3rd edn, J M Poehlman*

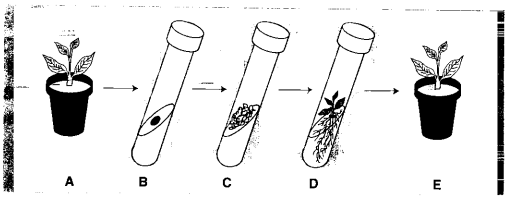


Figure 4 Tissue culture. Source: (as figure 3)

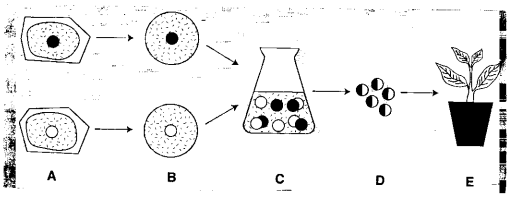


Figure 5 Protoplast fusion. Source: (as figure 3)

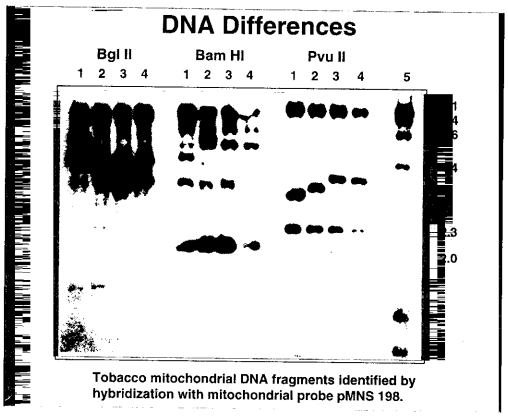


Figure 6 Y-1 restriction fragment length polymorphism. Tobacco mitochondrial DNA fragments identified by hybridization with mitochondrial probe pMNS 198. Source: US Patent application no 761,312

genetic makeup of Y-1 was verified by using genetic engineering techniques involving Restriction Fragment Length Polymorphism (RFLP) (figure 6).[9] The value of Y-1 to Brown & Williamson is reflected in the fact that Brown & Williamson had DNA Plant Technology make Y-1 into a male sterile plant. This procedure ensures that when a plant is grown it will not produce seeds that can be appropriated by others.

Brown & Williamson characterised its achievement in a patent filing as follows:

"By the present invention or discovery, applicants have succeeded in developing a tobacco plant that is agronomically and morphologically suitable for commercial tobacco production, ie, it closely

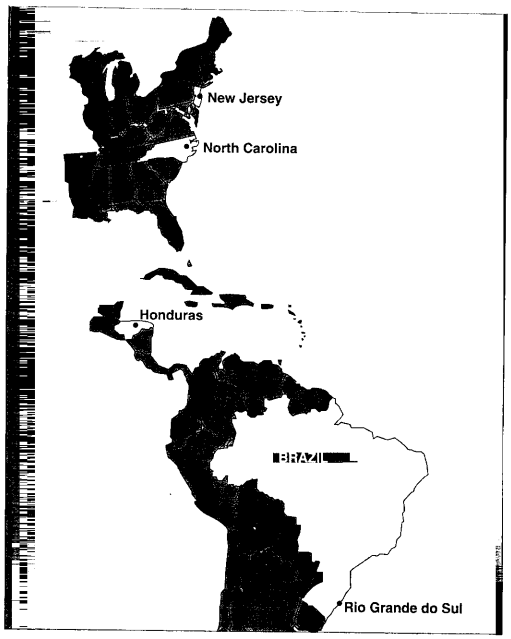


Figure 7 Where Y-1 was developed and grown

resembles SC 58, and provides a pleasant taste and aroma when included in smoking tobacco products, *yet it is possessed of the N rustica high-nicotine attribute.* So far as we know, this has not been accomplished before..."[10] [emphasis in original]

What was accomplished was the development of a tobacco plant with a high nicotine content – about 6 % – that grew well and could be used commercially.

The story of this high-nicotine plant continues in Rio Grande do Sul, Brazil (figure 7). DNA Plant Technology and Dr Chaplin both told us they saw Y-1 growing in Brazil in the 1980s. These farms were under contract to Souza Cruz Overseas, a sister company of Brown & Williamson.

We do not yet have all the details of how Y-1 came to be growing in Brazil. Until 13 December 1991, export of tobacco seeds or live tobacco plants was prohibited under Federal law unless a Tobacco Seed Plant Export Permit (Form TB-37) was granted by the USDA.[11] Such a permit could be granted only after satisfactory proof was offered that the seeds or plants were to be used solely for experimental purposes and then only in amounts of a half a gram or less.[12]

Brown & Williamson and DNA Plant Technology have each informed FDA that they believe the other may have been responsible for the shipment of Y-1 seed outside the US. We have asked both companies to furnish copies of any Tobacco Seed Plant Export Permits for Y-1.[13]

In reading the Brazilian Y-1 patent, we discovered that two related applications for the Y-1 variety of a tobacco plant were filed in the United States. Brown & Williamson filed a US patent application and a Plant Variety Protection Certificate Application in 1991.[14,15] The company also deposited samples of seeds from this plant with the National Seed Storage Laboratory in Fort Collins, Colorado.

When we attempted to obtain the Plant Variety Protection Certificate Application

- **Feb 21, 1991:** Brown & Williamson (B&W) files application for Plant Variety Protection Certificate
- **Sept 17, 1991:** B & W files U.S. Patent Application # 761, 312
- **Sept 16, 1992:** B & W files Brazilian Patent P1 9203690A
- **Feb 28, 1994:** B & W appeals rejection of U.S. Patent Application # 761, 312
- **March 14, 1994:** B & W withdraws application for Plant Variety Protection Certificate
- **March 16, 1994:** B & W abandons U.S. Patent Application # 761, 312

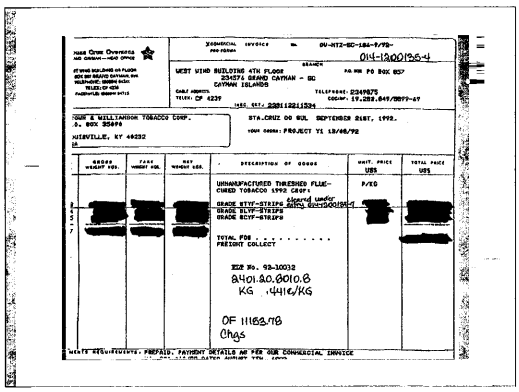
Figure 8 Chronology of significant events

from the USDA, we learned that the application was withdrawn about three months ago, on 14 March 1994. We were told that Brown & Williamson also withdrew all seed samples for this variety from the Seed Storage Laboratory.

We learned that the US patent application had been rejected by the patent examiner,[16] but that Brown & Williamson had filed an appeal on 28 February 1994.[17] However, two weeks later, on 16 March 1994, before receiving a response to their appeal, Brown & Williamson expressly abandoned the patent (figure 8).[18]

On Friday, 10 June 1994, DNA Plant Technology told us that it had been authorized by Brown & Williamson to tell FDA that Y-1 was never commercialised.

Mr Chairman, I wish to submit for the record two invoices filed with the US Customs Service in 1992 (figure 9). The invoices are addressed to Brown & Williamson Tobacco Corporation, Louisville, Kentucky from Souza Cruz Overseas. They refer to "Your Order



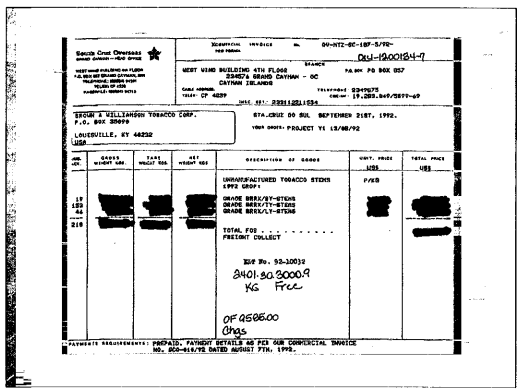


Figure 9 Invoices filed with US Customs Services in 1992

Project Y-1" and reveal that more than half a million pounds of Y-1 tobacco were shipped to Brown & Williamson on 21 September 1992.[19]

Four days ago, on Friday 17 June, after our questioning of DNA Plant Technology, and following our letter to Brown & Williamson indicating that Brown and Williamson had not been cooperative with our investigation, Brown & Williamson told FDA that, in fact, three and a half to four million pounds of Y-1 tobacco are currently being stored in company warehouses in the United States. More significantly, Brown & Williamson revealed that Y-1 had, in fact, been commercialised.

Mr Chairman, these brands of cigarettes – Viceroy King Size, Viceroy Lights King Size, Richland King Size, Richland Lights King Size, and Raleigh Lights King Size – were manufactured and distributed nationally in 1993 with a tobacco blend that contains approximately 10% of this genetically bred high-nicotine tobacco called Y-1.*

When we asked company officials why they were originally interested in developing a high-nicotine variety of tobacco, they told FDA that they wanted to be able to reduce tar, while maintaining nicotine levels.

The chemical manipulation of nicotine

Let me now move on to the second area. In April, the six major American cigarette companies released a list of 599 ingredients added to tobacco. Nicotine is not one of the additives listed. But, Mr Chairman, a number of chemicals on that list increase the amount of nicotine that is delivered to the smoker.

Around the time the list was made public, a great deal of interest was directed toward substances on the list that sounded particularly toxic. Among those frequently mentioned was ammonia. Many people may have wondered why the cigarette industry would add ammonia to tobacco. In fact, there are many uses of ammonia.[20] Our investigations have revealed an important one.

Let me refer to a major American tobacco company's 1991 handbook on leaf blending and product development. The handbook describes two ways that ammonia can be used in cigarette manufacture. One way is to interact with sugars in the tobacco. But it is the second way, the effect of ammonia and related compounds on the delivery of nicotine to the smoker, that is most striking. Let me quote from that handbook:

"[The ammonia in the cigarette smoke] can liberate free nicotine from the blend, which is associated with increases in impact and 'satisfaction' reported by smokers."

The handbook goes on to describe ammonia as an "impact booster":

"Ammonia, when added to a tobacco blend, reacts with the indigenous nicotine salts and liberates free nicotine. As a result of such change, the ratio of extractable nicotine to bound nicotine in the smoke

* See photograph published in the Autumn 1994 issue of *Tobacco Control* (1994; **3**: 203). – ED

may be altered in favor of extractable nicotine. As we know, extractable nicotine contributes to impact in cigarette smoke and this is how ammonia can act as an impact booster."

The important role that ammonia plays in the liberation of free nicotine is also emphasized in other parts of the handbook.

"This means that at the same blend alkaloid content, a cigarette incorporating [ammonia technology] will deliver more flavor compounds, including nicotine into smoke than one without it."

It is important to emphasize here that most of the nicotine in the average American cigarette is in the bound form. By that I mean it is not going to readily make its way to the smoker. Mr Chairman, I am not going to go into the details of acid-base, and vapor-phase chemistry, or the bioavailability of nicotine in the protonated versus the unprotonated form. Suffice it to say that only a fraction of the nicotine in the tobacco gets inhaled by the smoker. The handbook indicates that this ammonia technology enables more nicotine to be delivered to the smoker than if the ammonia technology is not employed.

What are the ammonia compounds used in this technology? The company handbook lists a number of different chemical compounds that can act as "impact boosters". Ammonia compounds known to be used include diammonium phosphate (DAP), ammonium hydroxide, and urea. In those countries, such as Germany, that do not allow DAP, other proprietary formulations are used.

To what are these compounds added? One of the most common places the ammonia and ammonia-like compounds are applied is to reconstituted tobacco.[21] When the cigarette is burned, the reconstituted tobacco serves as a source of ammonia in smoke. The amount of reconstituted tobacco can be as high as 25% of the tobacco in the cigarette. And we've seen ammonia compound levels as high as 10% in the reconstituted tobacco. Thus, as the company handbook goes on to state, the benefits of the reconstituted tobacco:

"come from being an ammonia source, as well as incorporating sugar-ammonia reactions. As a low alkaloid blend component, it also absorbs nicotine from higher alkaloid-containing components. [It thus becomes] ... a positive blend contributor rather than merely a filler."

The handbook also says that ammonia can be applied directly to the tobacco that goes into cigarettes.

How much additional nicotine does this technology impart? It is our understanding, based on smoke analysis described in the company handbook, that an experimental cigarette made of reconstituted tobacco treated with ammonia has almost double the nicotine transfer efficiency of tobacco.

How widespread is ammonia use in the industry? The company handbook states that many US tobacco companies use ammonia technologies. Until we have access to similar documents from other companies, we will not know whether other companies use it directly to affect nicotine levels.

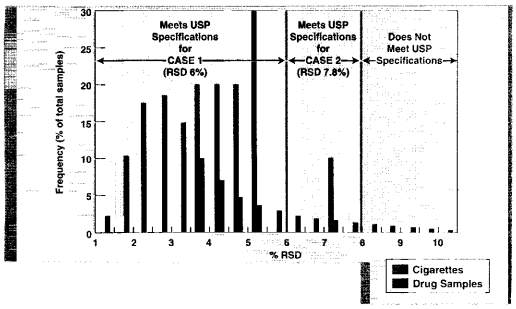


Figure 10 Comparison of the uniformity of drug samples and nicotine in 10 brands of cigarettes (11639 drug samples). RSD = relative standard deviation, being a measurement of content uniformity.

To determine how well nicotine content is controlled in cigarettes, FDA laboratories compared the content uniformity of drugs in either tablets or capsules to the content uniformity of nicotine in cigarettes. What is striking is how little the nicotine content varies from cigarette to cigarette, suggesting tight and precise control of the amount of nicotine in cigarettes.[22] In fact, as figure 10 shows, the nicotine content uniformity of the cigarettes tested meets drug content uniformity standards set by the US Pharmacopeia.

Mr Chairman, I have presented information on the control and manipulation of nicotine because I believe it raises certain important questions – questions that are even more important in light of the repeated assertions of the cigarette industry that it does not control or manipulate nicotine. Why spend a decade developing through genetic breeding a high-nicotine tobacco and adding that tobacco to cigarettes if you are not interested in controlling and manipulating nicotine? Why focus on the enhanced delivery of free nicotine to the smoker by chemical manipulation if you are not interested in controlling and manipulating nicotine?

The goals of control and manipulation

Why is there such interest in controlling and manipulating nicotine in cigarettes? Senior industry officials are aware that nicotine is the critical ingredient in cigarettes. Some in the industry have identified target levels of nicotine necessary to satisfy smokers' desire for nicotine. And the industry has undertaken research into nicotine's physiologic and pharmacologic effects.

TARGET RANGES

Let me give you one example of how a company has identified specific levels of nicotine necessary to satisfy smokers and has focused on how to achieve those levels. A company document describesconsumerpreferencetestingon"impact ", which according to the company correlates with nicotine. The document states that impact is a "high priority" attribute of cigarettes and is:

"... controllable to relatively fine tolerances by product development/product intervention... (by manipulating nicotine in blend/smoke...)."

This document goes on to describe an elaborate model for establishing the minimum and maximum nicotine levels tolerated by consumers. It states that the model provides "a median ideal point level for mg nicotine in smoke" for the population tested and a range of tolerable nicotine levels around this ideal point. After applying the testing method to a group of European smokers, for example, the document concludes:

"It is clear that consumers are less tolerant of decreases than they are of increases in nicotine delivery. By the time nicotine level falls to approximately 0.35 mg, 50% of consumers will be saying that the level of impact is so low they would reject the product. To reach the equivalent stage of 50% of consumers rejecting the product as having too high an impact level, a nicotine level of approximately 5.0 mg would be required. Again, it is important to note that there is a clear *upper* as well as lower rejection limit for nicotine in smoke."

It is thus clear that at least one major cigarette manufacturer is aware of the need to target nicotine delivery to levels necessary to satisfy smokers. In fact, as one tobacco flavour specialist has written, one of the most important goals of cigarette design is to "ensure high satisfaction from an adequate level of nicotine per puff", and that even cigarettes with reduced levels of nicotine and tar must have this property.[23]

Physiologic and pharmacologic effects of nicotine

Publicly available information, including recently released documents, reveals much about the industry's knowledge of the drug-like effects of nicotine.

I will begin by describing several studies commissioned by the tobacco industry. As I go through them, Mr Chairman and members of the Subcommittee, ask yourselves: Are these the kinds of studies that would be conducted by an industry interested only in the flavour or taste of nicotine?

On 16 May 1994, Brown & Williamson made available previously unreleased results of research that had been conducted more than 30 years ago. A review of this research, known as the Project Hippo studies, documents that the industry was interested in the physiologic and pharmacologic effects of nicotine as early as 1961.

The first report, known as Project Hippo I, contained an extensive discussion of the effects of nicotine in the body.[24] This included, for example, the effects of nicotine on the central nervous system.

Project Hippo II is an interesting study of what was, in the early 1960s, the newly evolving field of tranquilizers.[25] Let me quote from the opening paragraph of the summary of the Final Report on Project Hippo II:

"The aim of the whole research "HIPPO" was to understand some of the activities of nicotine – those activities that could explain why cigarette smokers are so fond of their habit. It was also our purpose to compare these effects with those of the new drugs called "tranquilizers", which might supersede tobacco habits in the near future."

Figure 11 Tobacco advertisement from the 1940s.

The comparison of the drug-like effects of nicotine and tranquilizers was not exactly a well-kept secret. Even in the 1940s you could pick up a magazine and see an advertisement like the one shown in figure 11. What seems to be new about the Hippo study was that it represented a serious commitment by a tobacco company to a scientific examination of this pharmacologic property.

Another report released with Hippo and conducted in the 1960s is called "*The fate of nicotine in the body*".[26] It reviews the state of knowledge about the distribution of nicotine in the body and presents the results of studies on nicotine metabolism in a group of smokers. The report states:

"The numerous effects of nicotine in the body may, at first, be conveniently measured by various physiological and pharmacological experiments."

The studies involved the use of radiolabelled nicotine in both humans and animals, which provided very sophisticated knowledge of the absorption and distribution of nicotine in the body. This included a knowledge of how much nicotine is present in the blood of smokers; how this nicotine is distributed; how it is excreted; and what variables affect the duration of a nicotine blood level.

It is clear that such research would be of interest to the industry only if the industry were concerned with the physiological and pharmacological effects of nicotine. Certainly, this is not consistent with the industry's representation that nicotine is of interest to it only because of flavour and taste.

Mr Chairman, we believe that the studies released by Brown & Williamson are relevant to the determination of whether nicotine-containing cigarettes are drugs for purposes of the Federal Food, Drug, and Cosmetic Act. And Brown & Williamson is not the only company that apparently has been involved in research on nicotine's physiologic and pharma-

cologic effects. Thanks to this Subcommittee's work, we now know that Philip Morris was conducting nicotine addiction research. We are also aware of research utilising electroencephalographic measurements to monitor the biological effects of nicotine on brain function at both RJ Reynolds[27–30] and Philip Morris.[31]

Major projects undertaken by at least two companies to develop cigarette alternatives also demonstrate that the industry understands that nicotine is the critical ingredient they are delivering to smokers.

It is widely known that in the late 1980s RJ Reynolds Corporation developed and test-marketed a cigarette alternative called Premier. It was smokeless and virtually tobacco free. It was essentially a nicotine delivery system. To make sure that Premier would be an acceptable alternative to smokers, RJ Reynolds conducted human studies to determine whether the nicotine from Premier and from a standard cigarette was absorbed into the blood of research subjects, metabolised, and excreted at the same rate.[32]

Recent reports in the media reveal that Brown & Williamson, too, launched an effort to develop a cigarette alternative. It was referred to as "Ariel". Brown & Williamson's own documents reportedly refer to Ariel as "a nicotine delivery device". One of the applicants for the patent for Ariel was Charles Ellis of British American Tobacco (BAT), Brown & Williamson's corporate parent. Ariel was composed of two parts: a source of nicotine and aerosol, and a heating material such as tobacco that served to heat the nicotine and cause the release of the nicotine and the aerosol.[33]

Mr Chairman, we further believe that recent reports in the media also may be relevant to the determination of whether nicotine-containing cigarettes are drugs.

Let me quote some of the recently reported statements of officials from one company that reveal a recognition of nicotine's drug-like effects:

"Nicotine is not only a very fine drug, but the techniques of administration by smoking has (sic) considerable psychological advantages."[34]
"... nicotine is a very remarkable, beneficent drug that both helps the body to resist external stress and also can, as a result, show a pronounced tranquilizing effect."[35]

These statements were apparently made by Sir Charles Ellis, a member of the Royal Society of London, who served as science advisor to the BAT Company board. He was responsible for advising the establishment of the company's research and development centre in Southampton, England. He was also responsible for advising on the research operations of BAT's associate companies.[36] Two of his recently reported statements are particularly striking. One statement was made in 1962:

"Smoking is a habit of addiction."[35]

But perhaps the most striking statement attributed to him is one from a meeting of company scientists in 1967:

"Sir Charles Ellis states that BATCO is in the nicotine rather than the tobacco industry."[37]

These statements are echoed by those made in an internal company document by another senior scientist at a British tobacco company:

"There is now no doubt that nicotine plays a large part in the action of smoking for many smokers. It may be useful, therefore, to look at the tobacco industry as if for a large part its business is the administration of nicotine (in the clinical sense)."

These statements are consistent with the quotes from William L Dunn, an official of Philip Morris, that I cited for you in my testimony last March.

"Think of the cigarette pack as a storage container for a day's supply of nicotine."
"Think of the cigarette as a dispenser for a dose unit of nicotine."
"Think of a puff of smoke as the vehicle for nicotine."
"Smoke is beyond question the most optimized vehicle of nicotine..."

Other scientists are quoted in a 30 May 1963 paper that is reported to have been produced for Brown & Williamson's sister company, the BAT Company, and labelled "*Confidential. A tentative hypothesis on nicotine addiction.*"[38] As reported, it contains a number of statements regarding the powerful effect of nicotine on the body:

"Chronic intake of nicotine tends to restore the normal physiological functioning of the endocrine system, so that ever-increasing dose levels of nicotine are necessary to maintain the desired action. Unlike other dopings, such as morphine, the demand for increasing dose levels is relatively slow for nicotine."

Other statements reportedly made in this paper speak directly to the addictive nature of nicotine. The report goes on to describe what happens when a chronic smoker is denied nicotine:

"A body left in this unbalanced state craves for renewed drug intake in order to restore the physiological equilibrium. This unconscious desire explains the addiction of the individual to nicotine."

Conclusion

The information that we have presented today has been the result of painstaking investigation. We now know that a tobacco company commercially developed a tobacco plant with twice the nicotine content of standard tobacco, that several million pounds of this high-nicotine tobacco are currently stored in warehouses, and that this tobacco was put into cigarettes that have been sold nationwide. We now know that several tobacco companies add ammonia compounds to cigarettes, and that one company's documents confirm that one of the intended purposes of this practice is to manipulate nicotine delivery to the smoker. And we now know that some in the industry have identified target ranges of nicotine delivery. These findings lay to rest any notion that there is no manipulation and control of nicotine undertaken in the tobacco industry.

It is equally important to lay to rest, once and for all, the industry's assertion that nicotine is not addictive. Up until very recently, the tobacco industry was able to claim that it did not believe that nicotine was addictive. The release of company documents, and the testimony of company scientists before this Subcommittee, have opened a window on what some senior tobacco officials knew about nicotine's physiological and addictive properties, as much as 30 years ago.

One important thing that every teenager in this country needs to know before deciding to smoke his or her first cigarette is how one cigarette industry official viewed the business of selling cigarettes:

"We are, then, in the business of selling nicotine, an addictive drug..."[39]

1 Kessler DA. Statement on nicotine-containing cigarettes. Testimony before House Subcommittee on Health and the Environment, 25 March 1994 (see *Tobacco Control* 1994; **3**: 148–58).
2 21 USC § 321(g)(1).
3 Republican Federativa do Brasil, Institute Nacionel da Propriedade Industrial, PI 9203690A, "Variendade de fumo geneticanente estavel e planta de fumo", issued to Brown & Williamson Tobacco Corporation, 4 June 1993.
4 Brazilian Patent No PI 9203690A. US Department of State, official English translation.
5 Letter of JW Johnson, Chief Executive Officer, RJ Reynolds Tobacco Company, to DA Kessler, Commissioner, US Food and Drug Administration. RJ Reynolds Tobacco Company, Winston-Salem, North Carolina; 28 February 1994.
6 Chaplin JF. Tailoring tobacco plants to meet future demands. *World Tobacco* October 1978; **62**: 145–9.
7 Chaplin JF. Breeding for varying levels of nicotine in tobacco. *Proceedings from a symposium on recent advances in the chemical composition of tobacco and tobacco smoke.* Raleigh, North Carolina, 1977: 328–39.
8 [Anon]. Evolving techniques of making cigarettes milder. *World Tobacco* April 1979; 93–101.
9 US patent no 761,312, "Filing of utility patent application," Figure 1.
10 US patent no 761,312, "Appellant's brief on appeal," p 6.
11 7 USC §516. (Tobacco Seed and Plant Exportation Act, repealed on 13 December 1991)
12 7 CFR 34.4(b).
13 DNA Plant Technology did provide a copy of a Phytosanitary Certificate. This document, which certifies that exported plants or seeds conform with phytosanitary regulations of the importing country, was issued to DNA Plant Technology by US Department of Agriculture, Plant Protection and Quarantine, to facilitate importation of 20 g of tobacco pollen into Brazil. 20 March 1990.
14 US patent no 761,312, filed 17 September 1991.
15 Plant Variety Protection Certificate Application, PV No 9100119, filed 21 February 1991, US Department of Agriculture. (Referenced in US patent no 761,312, "Filing of utility patent application," on p 1 – unable to obtain copy of application from USDA).
16 US patent no 761,312, "Rejection of claims", 10 July 1992.
17 US patent no 761,312, "Appellant's brief on appeal", filed 28 February 1994.
18 US patent no 761,312, "Express abandonment of patent application", filed 16 March 1994.
19 Redacted copies of US Customs Service Invoices for Brown & Williamson, dated 21 September 1992.
20 For example, ammonia has been used in efforts to denicotinize cigarettes (US patent no 4,215,706) and, in reconstituted tobacco, for its adhesive properties (US patent no 5,159,942).
21 Reconstituted tobacco can be made (one of several methods) by mixing tobacco stems, dust, and other scraps, adding a liquid solvent to form a "slurry", and then extracting the liquid and pressing the remaining mixture into a flat sheet. Almost all US cigarettes contain some reconstituted tobacco. (Vogues E. Tobacco Encyclopedia, published by *Tobacco Journal International* 1984: 389–90.)
22 US Food and Drug Administration, Center for Drug Evaluation and Research, Division of Drug Analysis. Report on analysis of packages of cigarettes. 4 April 1994.
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33 US patent no 3,356,094, Col 1: 8–10.
34 Sir Charles Ellis, Scientific Advisor to the Board of British-American Tobacco Co, July 1962 (as reported by Hilts PJ, in the *New York Times*, 16 June 1994).
35 Sir Charles Ellis, Scientific Advisor to the Board of British American Tobacco Co, July 1962 (as reported by Harris R, for National Public Radio, 14 June 1994).
36 Hutchison K, Gray JA, Massey H (chapter authors). Biographical memoirs of fellows of the Royal Society of London: Chapter on Charles Drummond Ellis. London: Royal Society 1981; **27**: 199–233.
37 Excerpt from a British American Tobacco Company research chronology from June of 1967 (as reported by Hilts PJ, in the *New York Times*, 17 June 1994).
38 Excerpt from a 30 May 1993 British American Tobacco Company internal document entitled "Confidential: a tentative hypothesis on nicotine addiction" (as reported by Hilts PJ, in the *New York Times*, 17 June 1994).
39 Excerpt from a July 1963 Brown & Williamson Tobacco Corporation internal document, authored by its General Counsel Addison Yeaman, analysing whether the company should acknowledge the hazards of cigarettes or remain quiet (as reported by Hilts PJ, in the *New York Times*, 7 May 1994).